

REMARKS

Claims 1-4, 7, 12-13, 26-28, 53, and 57-58 are amended herein. Claim 54 is canceled. Claims 59-79 are new. Claims 1-16, 20, 22-53 and 57-79 are pending.

Interview Summary

On October 24, 2008, the Examiner and the undersigned agent had a telephone conversation during which they discussed claim 1 with respect to Biswas and Burl references. No agreement was reached. The arguments set forth during the interview are summarized below.

Response to Rejection under 35 USC §103(a)

Claims 1-18, 20-56 and 58 were rejected under 35 U.S.C. 103(a) as being unpatentable over Biswas et al, US 7,197,074 in view of Burl, US 5,940,145. Applicants respectfully traverse.

As amended, claim 1 now recites (emphasis added):

A computer readable storage medium encoded with computer executable instructions for controlling a process to perform a computer implemented method of determining a motion vector for encoding a block of a predicted video frame with respect to a reference video frame, the method comprising:

establishing a size for phase correlation blocks, the size for the phase correlation blocks being larger than the maximum allowable magnitude of the motion vector;

within an inner area of the phase correlation block of the predicted video frame, the inner area having a size equal to or less than the maximum allowable magnitude of a motion vector, identifying a number of highest phase correlation peaks between a phase correlation block of the predicted video frame and a corresponding phase correlation block of the reference video frame;

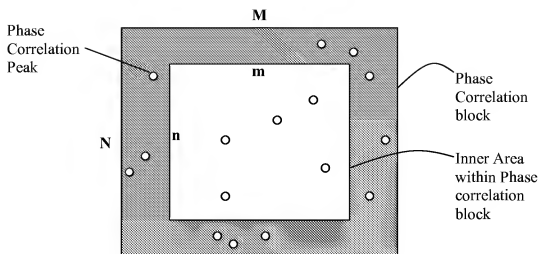
determining for each phase correlation peak identified in the inner area, a motion vector; and

selecting from the motion vectors, a motion vector that minimizes a distortion measure between the block and a reference block offset from the block by the motion vector.

Claim 27 recites a corresponding method for frame-level motion vector determination, and claims 28 and 53 recite a corresponding circuit apparatus and circuit means, respectively. For purposes of explanation, the claimed approach may be understood as having three stages of selection:

- a first selection stage: establishing a size for phase correlation blocks, the size of the phase correlation blocks being larger than the maximum allowable magnitude of the motion vector;
- a second selection stage: identifying a number of highest phase correlation peaks within a current phase correlation block of the size established in the first stage. These peaks are identified within an inner area of the phase correlation block that has a size less than the size of the maximum magnitude of the motion vectors. Each of these peaks is associated with a candidate motion vector from the current phase correlation block to a reference block; and
- a third selection stage: selecting a motion vector, from the identified candidate motion vectors at the second selection stage, that minimizes a distortion measure between the current phase correlation block and a reference block.

These stages enable an encoding system and method to select a motion vector for a block to be encoded with reduced computational complexity while without compromising image quality compared with the cited references. The following figure further illustrates the benefit provided by the claimed invention:



This figure illustrates a phase correlation block (the grey shaded area), which has a size of $M \times N$. There are a number of phase correlations peaks (white circles) within the phase correlation block, resulting from a phase correlation with a corresponding block of a reference frame. Each phase correlation peak has a location (x,y) which is the offset for a motion vector. Notice that only some of the phase correlation peaks fall within an inner area (the white rectangle) of the phase correlation block. This inner area has a size $(m \times n)$, where m and n are the maximum dimensions of the motion vector. As is apparent, “the size of the phase correlation blocks being larger than the maximum allowable magnitude of the motion vector” since M is larger than m and N is larger than n . For example, given $(m=48, n=48)$, the size of the phase correlation block may be $(M=64, N=64)$.

As claimed, a number of highest phase correlation peaks are identified within the inner area of the phase correlation block. Because this inner area is smaller than the phase correlation block itself, only phase correlations peaks within this area are considered as candidates for the highest peaks. This reduces the number of phase correlations peaks, and thus motion vectors that have to be evaluated, which is beneficial because it reduces the number of high complexity operations necessary to find a best motion vector. Elimination of

such phase correlation peaks is acceptable because the motion vectors corresponding to the location of such peaks have been found to be generally poor candidates, e.g., result in higher distortion or lower compression.

Thus, for the example figure, the 11 motion vectors for the phase correlation peaks falling in the gray area will not be evaluated in the subsequent selection stages in the claimed invention. Rather, at most only 5 motion vectors for the phase correlation peaks in the inner area are evaluated (indeed, some fewer number of motion vectors can be evaluated). This reduction of the potential motion vector candidates substantially improves the overall performance of the encoding process, and allows the invention to be readily scaled for higher resolution image processing.

Biswas does not disclose the elements of claim 1. First, Biswas does not disclose establishing a size of the phase correlation block, where the size of the phase correlation block is larger than the maximum allowable magnitude of the motion vector.

Second, Biswas does not disclose *“within an area of the phase correlation block of the predicted frame, the area having a size corresponding to the maximum allowable magnitude of a motion vector, identifying a number of highest phase correlation peaks between a phase correlation block of the predicted frame and a corresponding phase correlation block of the reference frame.”*

As a result, in Biswas, every phase correlation peak within his phase correlation block is initially treated as a candidate motion vector (col. 4:50-52). Using the example illustrated in the figure above, for the phase correlation block of size (M, N) , Biswas would consider every motion vector, including the 11 motion vectors for the phase correlation peaks falling in the gray area, and at best screen them using other methods. Because every motion vector in

the phase correlation block is treated as a potential candidate motion vector, Biswas has more motion vector candidates to be evaluated than the claimed invention.

At the third stage, from the identified candidate motion vectors in the inner area the claimed invention selects a motion vector that minimizes a distortion measure between the current phase correlation block and a reference block. Because of the earlier elimination of certain motion vectors outside of the inner area, generally fewer motion vectors need to be evaluated to determine which provides a minimized distortion. In contrast, due to the complexity of Biswas' scheme, Biswas' correlation and validation process is terminated as soon as the first candidate motion vector is found which has less than a "selected limit for error" threshold (col. 5:62-6:5). This threshold is obviously a maximum allowable amount of error, not a minimum. Thus, by terminating with the first motion vector having less than a maximum error, Biswas does not select the motion vector that minimizes the distortion measure.

Further, the disadvantages of Biswas described above inevitably lead to another significant disadvantage: Biswas does not scale well to higher resolution images, such as Standard Definition and High Definition. For example, if small phase correlation blocks are used, such as 32x32 and 64x64 examples given by Biswas, then only small motion vectors are produced (col. 3:61). However, limiting candidate vectors in this fashion leads to poor compression efficiency at these high resolution images. On the other hand, if larger phase correlation blocks are used with Biswas, such as 128x128 or 256x256, the potential number of phase correlation peaks could be in hundreds or even more, depending on the image content and/or noise, etc. In such case, Biswas' correlation and validation technique becomes prohibitively computationally complex, since hundreds of vectors need to be evaluated. To deal with this problem, Biswas' raises the error threshold to select a good enough candidate

motion vector, which, in turn, will lead to poor compression efficiency, and again likely result in the select of a motion vector that does not minimize distortion.

Burl does not remedy the deficiencies associated with Biswas. Burl discloses a method for motion compensated image processing (Abstract). Burl discloses selecting a few of the highest peaks (e.g., 5 highest peaks) in the correlation surface (col. 2:59-65). However, similar as Biswas, Burl does not disclose *establishing a size for phase correlation blocks and the size of the phase correlation blocks being larger than the maximum allowable magnitude of the motion vector*. Using the same example illustrated in the figure above, for a phase correlation block of size ($M=64$, $N=64$), Burl has to search an array of size $64 \times 64 = 4096$, while the claimed invention only needs to search an array of size $48 \times 48 = 2304$, which is almost half of Burl's search space.

Based on the above remarks, Applicants respectfully submit that for at least these reasons independent claims 1, 27-28, 53 and 57-58 are patentably distinguishable over Biswas and Burl, both individually and in combination. Therefore, Applicants respectfully request that Examiner reconsider the rejection, and withdraw it.

The dependent claims are also patentable over the cited references, both because each depends from patentable independent claims, respectively, and because each also recites its own patentable features. Therefore, Applicants respectfully submit that claims 1-16, 20, 22-55 and 57-58 are patentably distinguishable over the cited references.

Response to Rejection under 35 USC § 103(a)

Claims 6 and 33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Biswas and in view of Zhang, US 6,449,312. Claims 10-11 and 37-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Biswas in view of Aude. Claims 20, 21, 47-48, and

57-58 are rejected under USC §103(a) as being unpatentable over Biswas in view of Burl, in further view of Biswas et al. “A Novel Motion Estimation Algorithm Using Phase Plane Correlation for Frame Rate Conversion” (Biswas2).

Response to Rejection under 35 USC § 103(a) over Biswas in view of Zhang

Zhang does not remedy the deficiencies of Biswas. Zhang discloses a method of estimating motion in video using block matching metric. Zhang’s estimation process searches a search window in a reference frame to try to find a match for an image block in a current frame in pixel domain.

First, Zhang’s method of motion estimation is fundamentally different from the method disclosed by both the claimed invention and Biswas. Zhang searches for the best motion vector candidate by starting at a certain point, and then moving along a search path according to various criteria in pixel domain. Thus, there is no inherent limitation in how far from the starting point the search path can continue. The decision to stop at a given point (i.e., search area) is based on the amount of time the search takes and the expected compression ratio (col. 3:20-40 and FIG. 1). The claimed invention, however, only considers motion vector candidates whose magnitudes are restricted to the noted limits (“search area”) in phase correlation surface domain.

Zhang’s search window is not equivalent to the phase correlation block dimensions (M and N) as claimed. In Zhang, motion estimation in frame mode and field mode is conducted in a given search range, e.g., motion vector search window, and motion displacements (e.g., motion vector magnitude) can be as large as the search window (col. 1:36-44 and col. 3:40-45). In contrast, in claim 6, the phase correlation block dimensions are specifically claimed as being more than twice as large as the motion vector search window. For example, assuming that the motion vector size used in both Zhang and the claim 6 is 128. Then Zhang would use

a block size of 128x128, but the claimed invention would use a phase correlation block dimensions of 272x272 (i.e., $2S+16$), instead of 128x128. This is beneficial for the operation of claim 1, but this modification of the Biswas would seriously impair the performance of Biswas, since it would increase the size of his search area more than 450% (a search area of 272x272 pixels is 4.51 times as large as a search area of 128x128 pixels). As noted above, increasing Biswas' block size increases the number of motion vectors that he processes, resulting in decreased performance, and a statistical decrease in the overall image quality. See, MPEP 2143.01, Paragraph V, "If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. In re Gordon, 733 F.2d 900, 221 USPQ 1125". The choice of M and N in this matter is beneficial in that it ensures that the phase correlation block is large enough to fully cover the entire search area for a macroblock of size 16x16 located at the center of the phase correlation block.

Thus, claims 6 and 33 are patentable over Biswas and Zhang, both individually and in combination. Other dependent claims recite similar language and are also patentable over Biswas and Zhang, both individually and in combination.

The claims not mentioned above depend from their respective base claims, which are patentable over Biswas and Zhang, both individually and in combination. In addition, these claims recite other features not included in their respective base claims. Thus, these claims are also patentable over Biswas and Zhang, both individually and in combination.

Response to Rejection under 35 USC § 103(a) over Biswas in view of Aude

Claims 10-11 and 37-38 are rejected under 35 USC §103(a) as being unpatentable over Biswas in view of Aude. Aude teaches coherent and windowed sampling with A/D

converters, which is sole reason Aude is cited by the Examiner. But Aude does not remedy the deficiencies of Biswas and Zhang as set forth above.

Thus, claims 10-11 and 37-38 are patentable over Biswas and Aude, both individually and in combination. Other dependent claims recite similar language and are also patentable over Biswas and Aude, both individually and in combination.

The claims not mentioned above depend from their respective base claims, which are patentable over Biswas and Aude, both individually and in combination. In addition, these claims recite other features not included in their respective base claims. Thus, these claims are also patentable over Biswas and Aude, both individually and in combination.

Response to Rejection under 35 USC § 103(a) over Biswas in view of Burl and Biswas2

Claims 20, 21, 47-48, and 57-58 are rejected under USC §103(a) as being unpatentable over Biswas in view of Burl and in further view of Biswas2. Biwas2 does not remedy Biswas and Burl. Biswas2 teaches using phase plane correlation for frame rate conversion. Biswas2 uses a threshold value to evaluate the similarity between the current block of interest and its 8 neighbors (Section 3). However, this threshold is unrelated to the number of the phase correlation peaks based on a maximum allowable motion vector magnitude. Further, because Biswas2 is merely a further elaboration of Biswas (that is, Biswas2 appears to include everything in Biswas, plus additional content), the combination of these references provides nothing more than what Biswas2 alone discloses. As such, Biswas2 does not disclose the claimed features. Therefore, claims 20, 21, 47-48, and 57-58 are patentable over Biswas2 and other cited references, both individually and in combination.

In sum, all of the claims are patentable over all cited references, both individually and in combination.

Applicants note that narrowing amendments made in response to a previous Office Action has been reversed in this amendment. In view of the Federal Circuit's decision in *Hakim v. Cannon Avent Group PLC*, 81 U.S.P.Q.2d (BNA) 1900 (Fed. Cir. 2007), Applicants hereby rescind any disclaimer that may have resulted from the previous amendments or arguments associated therewith.

Conclusion

Applicants respectfully submit that the pending claims are allowable over the cited art of record for at least the above reasons and request that the Examiner allow this case. The Examiner is invited to contact the undersigned in order to advance the prosecution of this application.

Respectfully submitted,
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